

Fiber Optic Splicing

by [FOA](#)

Fusion splicing is the process of fusing or welding two fibers together usually by an electric arc. Fusion splicing is the most widely used method of splicing as it provides for the lowest loss and least reflectance, as well as providing the strongest and most reliable joint between two fibers.

Virtually all singlemode splices are fusion. Multimode fibers can be harder to fusion splice as the larger core with many layers of glass that produces the graded-index profile are sometimes harder to match up, especially with fibers of different types or manufacturers.

Fusion splicing may be done one fiber at a time or a complete fiber ribbon from ribbon cable at one time. First we'll look at single fiber splicing and then ribbon splicing.

Fusion splicing machines are mostly automated tools that require you preset the splicing parameters or choose factory recommended settings that will control the splicing process itself. All require the use of a precision fiber cleaver that scribes and breaks (cleaves) the fibers to be spliced precisely, as the quality of the splice will depend on the quality of the cleave. Most splicing machines come with a recommended cleaver.

Proper use of both the splicing machine and the cleaver require carefully following the manufacturer's directions. Each manufacturer's product is slightly different and requires somewhat different procedures. Reading the manuals and practice with the machine are important, especially if the operator has not been trained on the particular splicer in use.

Automatic Fiber Alignment

The ends of the fibers are on moveable stages which are used to align the fibers and set the end gap automatically. During the automated process, the splicer will align the fibers using one of two methods:

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Optical Core or Profile Alignment Systems (PAS)

Optical Core Alignment (also called "Profile Alignment"), an optical alignment technique, is used by many models of fusion splicers. The two fibers are illuminated from two directions, 90 degrees apart. From the images in a video camera, software recognizes the core of the fibers and aligns them automatically using movable stages. The software also estimates splice loss after the fusion splicing is complete. Ribbon splicers typically use profile alignment.

Local Injection and Detection (LID System)

LID Core Alignment uses "Local Injection and Detection" of light. Light is coupled into the

fiber by bending the fiber and shining a light source (LED or laser) on the outside of one fiber, so some light is coupled into the core. On the other fiber, the bend causes macrobending losses that are measured by a photodetector, providing a relative indication of light transmission through the splice. The splicer measures light coupling through fiber while moving fibers on actuators to get best transmission which means the fibers are optimally aligned. The LID system also checks transmission after splicing to estimate splice loss. Both techniques work well with most fibers. Refer to the instruction manual or ask the manufacturer if there is any question about using the splicer with the fiber you are installing. Splicing machines also generally have a heating device for heat shrinking a protective sleeve over the finished splice to protect it from moisture or other environmental hazards. An alternate method using clamp-on protectors.

In addition to the splicer and cleaver, the tech doing the splicing will need a set of cable preparation and fiber stripping tools. Since much fusion splicing is done in the outside plant, the splicing tech should have tools to handle all types of loose tube cable, both gel-filled and dry water-blocked, with various jacket styles, armor, etc.

Fusion splicing requires stripping a longer length of bare fiber than termination, so the choice of stripper is important. There are three types of fiber strippers available, known as (from Left) the Miller Stripper, No-Nik and Micro-Strip. All three can work equally well, and most techs choose the one they are most familiar with. The Miller, perhaps the most rugged, has the disadvantage of being "right-handed." The Micro-Strip allows setting strip length for consistent strips. The No-Nik is careful with the fiber but requires careful cleaning. Most strippers are "sized" for the fiber coatings to be removed, so ensure you have the proper stripper for the fiber being stripped. Whichever stripper is used, care must be taken to not nick the fiber during the stripping process as it can cause cracks that may lead to fiber failure sometime in the future. Strippers require careful cleaning and immediate replacement if they become damaged or worn.

The Fusion Splicing Process

Strip jacket, removing an adequate amount of jacket, usually 2-3 m, for splicing and dressing the buffer tubes and fibers in the splice closure. Leave the proper amount of strength members to attach the cable to the closure. Refer to the splice closure directions for lengths needed. Clean all water-blocking materials using appropriate cleaners.

Remove buffer tubes exposing fibers for splicing. Generally splice closures will require ~1 m buffer tubes inside the closure to and ~ 1 m fiber inside the splice tray. Clean all water-blocking materials.

Prepare the fibers to be spliced

The process is the same for all splice types: strip, clean & cleave.

Each fiber must be cleaned thoroughly before stripping for splicing.

When ready to splice a fiber, strip off the buffer coating(s) to expose the proper length of bare fiber

Clean the fiber with appropriate wipes

Cleave the fiber using the process appropriate to the cleaver being used

Place the fiber into the guides in the fusion splicing machine and clamp it in place

Repeat for the other fiber to be spliced

Running the splicer program

Choose the proper program for fusion splicing the fiber types being spliced

The splicer will show the fibers being spliced on the video screen.

Fiber ends will be inspected for proper cleaves and bad ones like the one on the right above will be rejected.

Automated Splicing

Fibers will be moved into position

Prefuse cycle will remove any dirt on the fiber ends and preheat the fibers for splicing
The fibers will be aligned using core alignment method for that splicer
The fibers will be fused by an automatic arc cycle that heats them in an electric arc and feeds the fibers together at a controlled rate
When fusion is completed, the splicing machine will inspect the splice and estimate the optical loss of the splice. It will tell the operator if a splice needs to be remade.
The operator will remove the fibers from the guides and attach a permanent splice protector by heat-shrinking or clamping clam shell protectors.

Evaluating Splices

Good Splices

Visually inspect splice after the program has run, using both X and Y views. Some flaws that do not affect optical transmission are acceptable, as shown. Some fibers (e.g. fluorine-doped or titanium coated) may cause white or black lines in splice region that are not faults.
(Graphic from Sumitomo manual)

Bad Splices

Some flaws are unacceptable and require starting the splicing process over. Some, like black spots or lines, can be improved by repeating the ARC step, but never more than twice. For large core offsets, bubbles or bulging splices, always redo. (Graphic from Sumitomo manual)

Splice Problem Troubleshooting

Here are some common problems and likely causes.

Not Fused Through

Fusion current too low / Prefusion time too short

Matchheads

Contaminated electrodes / Fusion current much too high / Prefusion time much too long
/Prefusion current much too high /Autofeed too small /Gap too large

Constriction

Current too high / Feed rate too slow / Prefusion time too long / Prefusion current too high /
Gap too wide / Contaminated electrodes

Enlargement

Autofeed too fast / Incorrect current

Bubble or Inclusion

Contaminated fiber end faces / Poor cleave / Fusion current too high / Prefusion current or

time too low

Additional Problems

Fusion splicers generally have stored programs for most fibers and the user can modify those program parameters or create new ones. Refer to the instruction manual or ask the manufacturer if there is any question about using the splicer with the fiber you are installing. It is sometimes necessary to splice older fibers, either in restoration or modifying networks. Older fibers may become brittle and hard to strip